

II. Quabbin Reservoir Watershed Description

The Quabbin Reservoir is located in the valley of the impounded Swift River. The watershed is located in the upper reaches of the Chicopee River drainage basin in Massachusetts (**Figure 2**). The reservoir has a watershed area of 119,940 acres including the reservoir's surface area. This Section provides a general description of watershed conditions. A more detailed description of the watershed is located in the *Watershed Protection Plan Update* (2000).

A. Water Resources

All inland waters within the Commonwealth of Massachusetts are classified under the Massachusetts Surface Water Quality Standards 314 CMR 4.03. These classifications are based on actual or intended use of the water resource. Class A waters are designated in the Surface Water Quality Standards as sources of public (drinking) water supply. The Massachusetts Department of Environmental Protection (DEP) classifies all surface waters within the Quabbin Reservoir watershed as Class A waters. All Class A waters are also classified as Outstanding Resource Waters (ORWs) as are certified vernal pools and certain designated Areas of Critical Environmental Concern (ACEC).

1. Hydrologic Features

The hydrology of a reservoir's watershed plays an important role in defining its water quality. The following section describes hydrologic events: precipitation, evaporation, and streamflow patterns in the Quabbin Reservoir watershed; inflows to and outflows from the Reservoir; and general hydrodynamic characteristics of the reservoir.

Figure 3 is a map of the hydrologic features (e.g., tributaries, ponds, larger wetlands) in the Quabbin Reservoir watershed. The reservoir receives the natural inflows of direct precipitation onto the water surface, from tributary rivers and streams (including baseflow and runoff components) and through stormwater runoff or snowmelt from drainage areas around the shoreline. In addition, the Ware River is diverted on a seasonal basis to Quabbin Reservoir through the Quabbin Aqueduct through Shaft 11A. Transfers from the Quabbin Reservoir through the Quabbin Aqueduct provide the Wachusett Reservoir, a terminal water supply reservoir, with more than 50% of its annual inflow.

Table 4 DCR Division of Water Supply Protection - Office of Watershed Management Planning Summary

All plans produced by OWM staff unless noted otherwise

Type of Plan	Latest Publication	Term	Next Planned Revision	History (Consultant)
Watershed Protection Plans				
Quabbin Reservoir/Ware River	2000	5-8 years	2008	1991 (Rizzo)
Wachusett Reservoir	2003	5 years	2008	1991 (Rizzo) 1998 (CDM)
Sudbury Reservoir System	1997	As Needed (Emergency Reserve - Watershed Protection Plan not required)		(CEI)
Land Management Plans¹				
Quabbin Reservoir	1995	10 years	2005	1961, 1972, 1986
Ware River	2003	10 years	2013	1986
Wachusett Reservoir	2001	10 years	2011	
Sudbury Reservoir System	2005	10 years	2015	
Public Access Management Plans				
Quabbin Reservoir	1998	10 years	2005	1988
Ware River	2000	10 years	2010	1988
Wachusett Reservoir	2003	10 years	2013	1996
Sudbury Reservoir System	2002	10 years	2012	1994
Other Plans and Reports				
OWM Fiscal Year Work Plan	2006	1 year	2007	2005
Land Acquisition Plan ²	1998	10 years	2005	
Emergency Action Plans (w/MWRA)	2004	Annual Review	2005	1993-1995 (GZA and GEI)
Stormwater Management	1999	As Needed		(CDM)
Agriculture	1998	As Needed		(CEI)
Highways/Railways Hazardous Material Release Control Project	1998	As Needed		(Rizzo)
Hazardous Materials Emergency Response Plans	1997	As Needed		(CEI)
Water Quality Reports				
Annual Water Quality Report	2004	1 Year	2005	Annually since 1987
Environmental Quality Assessments (Replaced Sanitary Surveys in 2000)	2004	5 years	On-going (1 sub-basin/year)	Sanitary Surveys: 1988-2000. EQAs: 2000-present

Source: DWSP, 2005

¹ Cutting plans are developed annually to guide specific forestry activities.

² A list of properties is developed semi-annually for review by the MWRA Board of Directors.

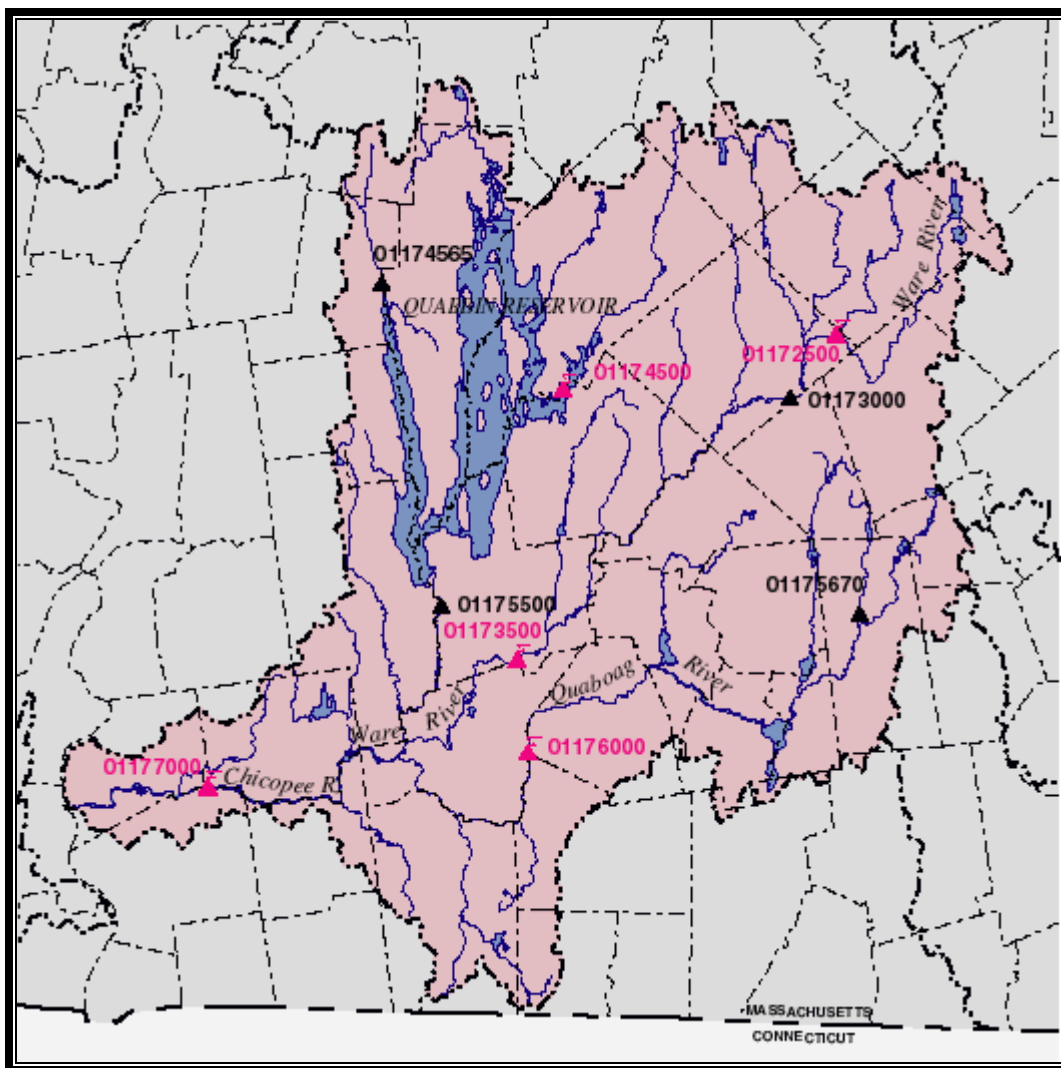


Figure 2 Chicopee River Drainage Basin Containing Quabbin Reservoir and Its Watershed

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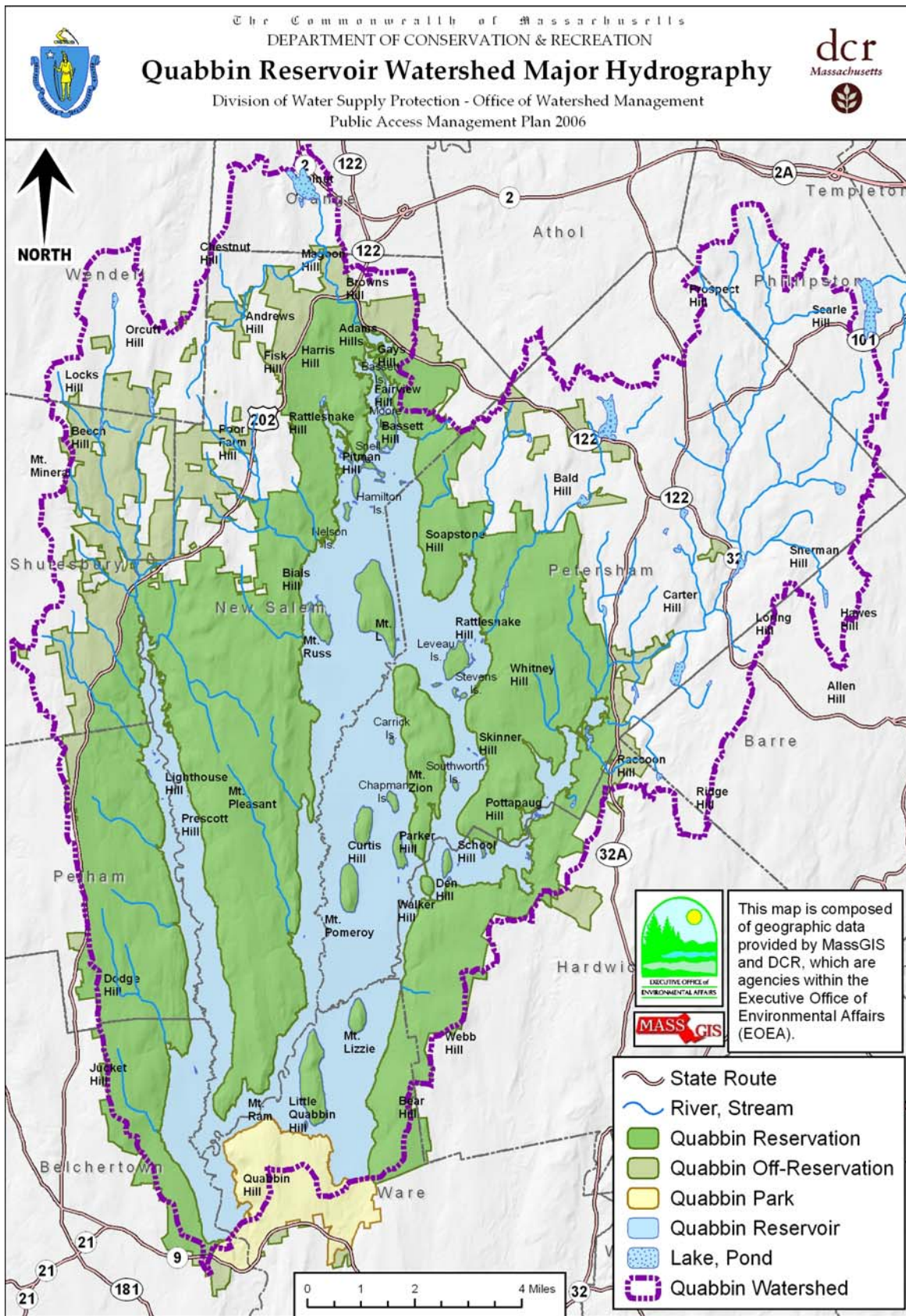


Figure 3 Quabbin Reservoir Watershed System

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2. Precipitation and Evaporation

Monthly rainfall in the Quabbin Reservoir watershed can vary significantly from year to year. Summer precipitation generally comes in high-intensity thunderstorms. The average annual precipitation at the DCR Quabbin Reservoir weather station in Belchertown has been 46 inches. Annual evapotranspiration in central Massachusetts has been estimated between 22 and 28 inches (Thornthwaite *et. al.*, 1958). While evaporation measured with an evaporation pan is about 39 inches in Massachusetts (Higgins, 1968), evaporation in lakes and reservoirs is usually lower. Annual evaporation from Quabbin Reservoir is estimated to be 22 inches.

3. Snow Survey

MDC has conducted a snow survey in the Quabbin Reservoir watershed since the 1930s. The purpose of the survey is to record the potential rise in reservoir elevation (potential inflow) as well as the flood potential of rivers and streams due to snowmelt. Prior to the filling of the Quabbin Reservoir, MDC monitored twelve snow survey stations in the Quabbin Reservoir watershed. Once the reservoir was filled, six of the twelve stations remained. OWM staff currently monitors six snow survey stations weekly, typically between January and April. OWM staff take six samples at each station using a snow density gage to measure snow depth and weight. The average depth and weight measurements are used to determine the average water content of the snow pack. Staff report average depth and water conversion figures as both “potential rise in reservoir elevation” and as “river and stream flood potential”. Over the past 22 years, the average annual snow depth at the six stations within the Quabbin Reservoir watershed has been 47.47" (MDC/DWM-CE, 2000).

4. Stream flow

Stream flow in the Quabbin Reservoir watershed, as in most of New England, has significant seasonal variations. Flows tend to be highest in the spring, due to snowmelt and high groundwater; and lower in the summer and early fall due to greater solar radiation and evapotranspiration. These seasonal changes are important since “high flow” water quality threats (e.g., streambank erosion) tend to occur in the spring, whereas “low flow” water quality threats (e.g., higher bacteria levels resulting from lower dilution) tend to occur in the summer and early fall. DCR staff monitor stream flow at selected sites where water quality samples are taken in the Quabbin Reservoir watersheds.

5. Inflows and Outflows

Inflows and outflows to Quabbin Reservoir are listed in **Table 5**. Direct precipitation accounts for almost 30% of the average annual inflow. Inflows from Quabbin Reservoir’s main tributary, the East Branch of the Swift River and direct inflow from shoreline, combined, account for about 34% of the annual inflow (on a long-term basis). Ware River transfers to the Quabbin are also a significant source of inflow, at about 9% of the annual inflow.

The largest outflow from Quabbin Reservoir is the Quabbin Aqueduct withdrawal for transfer into Wachusett Reservoir, which accounts for more than 60% of water that leaves the reservoir. Other significant outflows are evaporation and downstream release to the Swift River, which together account for almost another 30% of the outgoing water. Other smaller outflows include Chicopee Valley Aqueduct withdrawals for the Chicopee Valley service area and the flow over the reservoir’s spill way, which occur when the reservoir is full or almost full.

Table 5 Inflows and Outflows - Quabbin Reservoir

	<i>Area (sq. mi.)¹</i>	<i>Annual Flow (cfs)²</i>	<i>Annual Flow (mgd)²</i>	<i>Annual Flow (%)</i>
<i>Inflows:</i>				
Direct Precipitation	38	125	81	28
Ware River Transfers	96	39	25	9
Direct Inflow	40	78	51	17
East Branch Swift River	44	75	49	17
West Branch Swift River	12	24	16	5
Middle Branch Swift	11	21	14	5
East Branch Fever Brook	9	17	11	4
West Branch Fever Brook	5	9	6	2
Hop Brook	5	11	7	2
Dickey Brook	4	8	5	2
Other tributaries	20	40	26	9
<i>Outflows:</i>				
Quabbin Aqueduct	NA	238	154	63
Chicopee Valley Aqueducts	NA	18	12	5
Evaporation	38	68	44	18
Downstream Release	NA	42	27	11
Spillway	NA	9	6	2

Source: MDC/DWM, 1999

¹ Areas obtained from MDC, MWRA, and Rizzo Associates (1991a).

² Tributary inflows were estimated for this assessment by gage transposition using the USGS gauged records for the East Branch of the Swift River and Cadwell Creek. Ware River transfers and outflows were obtained from MDC records. Evaporation was estimated at 24.5 in/yr using the results of the 1995 modeling study for Wachusett Reservoir (CDM, 1995b).

B. DCR Land Resources

A major tenet of watershed management is protection through ownership of watershed lands. Owning and managing forest lands surrounding a public drinking water supply source is recognized as the most direct and proven method of protecting the water source's long-term quality: 1) A forested watershed provides the best quality water; 2) The purchase of undeveloped lands prevents its development; development can alter vegetation and drainage and introduce impervious areas and pollutants; 3) The purchase of vegetated buffers provides natural "treatment" or protection to reduce water quality impacts of future development; 4) The purchase of problem properties effectively halts the problem activity or use, and ensures proper clean up or re-vegetation of the site; and 5) Active management of watershed lands through proper forestry practices improves their pollution attenuation ability while reducing fire risk.

DCR owns the most sensitive lands within the 119,935 acre watershed of the Quabbin Reservoir. Sensitive lands are defined as the lands directly surrounding the reservoir and lands within 400 feet of tributaries to the reservoir. Presently, DCR owns 45% of the Quabbin Reservoir watershed (**Table 6**). In addition, 12, 440 acres, or 10% of the watershed is protected by other governmental agencies and private/non-profit groups. When full, the reservoir's surface area, 24,584 acres, comprises 21% of the watershed. DCR also protects watershed lands from development through acquisition of conservation restrictions (CRs). DCR now owns approximately 716 acres of CRs in the Quabbin Reservoir watershed.

Table 6 DCR Land Holdings

	<i>DCR Land Holdings² within Quabbin Reservoir Watershed</i>	
	<i>Acres</i>	<i>Percent of Watershed</i>
<i>MDC-Owned Land, 1985</i>	51,792	43%
<i>DCR-Owned Land, 2005</i>	53,611	45%
<i>Reservoir Area, 2005</i>	24,584	20%
<i>Other Government Agencies</i>	6,616	6%
<i>Private & Non-profit Agencies</i>	5,825	5%

Source: OWM/GIS, 2005

² Excluding the reservoir's surface area (i.e., land under water).

1. Land Use and Land Cover

Land use and land cover in a watershed influence the hydrology and water quality of its streams, lakes, and ponds. Both are important considerations to determine the appropriate protection measures for the watershed. Generally, the Quabbin Reservoir watershed is dominated by forest cover with sparse residential and limited agricultural land uses (Table 7).

Table 7 Land Cover and Land use Excluding the Reservoir

Watershed	Forest Cover	Wetland Cover	Agriculture	Residential	Commercial/Industrial	Open Water	Other
Quabbin Reservoir	87%	6%	3%	1%	0.1%	0.3%	3%

Source: MDC/DWM, 1999

2. OWM's Current Land Management Program

DCR/OWM owned lands include forests, shoreline areas, fields, and administrative areas. While OWM's land management practices historically focused on forestry, new responsibilities have been added to the task of managing DCR lands in recent decades. These include tasks associated with the land acquisition program since it began in 1970 and with other recent DCR initiated activities, such as wildlife habitat manipulation and public access controls. DCR/OWM's current and planned land management program in the Quabbin Reservoir Watershed is detailed in the *Quabbin Land Management Plan 1995-2004*. This Plan is currently being updated. The preponderance of forest cover surrounding the Quabbin Reservoir is reflected in the plan's emphasis on forest management activities. The most important goal for the Land Management Plan is to maintain the function of this watershed protection forest in both the short term (10 years) and long term (60 years).

OWM conducts active silviculture on approximately 1,500 - 2,000 acres per year on the Quabbin Reservoir watershed. This figure represents about 2 - 3% of the OWM ownership per year. Of this 2-3%, about 50% involves regeneration operations to produce new age classes of trees within the forest stand. Regeneration operations including: preparatory cutting, site preparation and enrichment planting, release of regeneration, intermediate cuttings, For any given forest stand under management, the frequency of return trips to harvest again (the cutting cycle) seldom exceeds once every 15-30 years, after a diverse stand has been established. While active management is beneficial for the long term, it is possible that harvesting activity could cause short-term problems. During 35 years of active silviculture on DCR/OWM watershed lands, no measurable water quality degradation has been associated with these practices.

The Rainforest Alliance's Smart Wood program evaluated DCR/OWM's management of the Quabbin forest in 1997, and granted it "green certified" status. Smart Wood is an internationally certified program that evaluates forest management operations for sustainability and state-of-the-art, forestry best management practices (BMPs). The DCR/OWM's Quabbin holding became the first public land in North America to achieve the status of "green certification," after an extensive independent evaluation by the team of Smart Wood experts. Part of the process involved comparing DCR/OWM's forestry BMPs to three other large water supply forests in the

Northeast. DCR/OWM's forestry BMPs compared very favorably with those required by other water suppliers.

Management of Non-Forested Lands

DCR/OWM is responsible for management and maintenance of all its lands, including the shoreline areas, fields, and administrative areas which do not fall under the Silviculture/Forestry program. In recent years, DWM has increased its use of different management techniques to aid related goals. An example of OWM's efforts is decreasing mowing frequency and keeping grass taller in key lawn areas along the shoreline to discourage Canada geese from nesting along the shoreline.

Management of New Acquisitions

OWM has many newly acquired parcels as a result of the land acquisition program. For each new acquisition, DWM staff performs an initial assessment of the property, identifies any hazardous waste issues (including location of underground storage tanks), evaluates forest stands, and makes decisions regarding demolition or maintenance of any structures on the parcel.

DCR/OWM forestry activities also include protecting the forest from white-tailed deer impacts, and wildfires, maintaining forest access roads (used for forest management, surveillance of public access, water sampling, and fire protection), and using BMPs.

C. Wildlife Resources

In recent years, wildlife resources have become an increasing concern among water supply professionals due to a new awareness of wild animal's potential to transmit pathogens combined with the fact that many wildlife species inhabit natural, forested areas that typify drinking water supply watersheds. The Quabbin Reservoir watershed is inhabited by a variety of wildlife species typical of New England forests, wetlands, and fields. The majority of these animals pose no risk to water quality. Certain species, however, are a concern because they are known to be possible carriers of waterborne disease pathogens and live in or near the water. These species have the potential to pose a threat to water quality in the Reservoir. For example, birds such as herring, ring-billed, or great black-backed gulls and Canada geese roosting on the reservoir or residing on the reservoir islands or shoreline may carry *Salmonella* and *Cryptosporidium*. Aquatic mammals such as beaver or muskrat, residing in the reservoir or in direct tributary streams or wetlands may carry *Giardia* or *Cryptosporidium*.

Prior to 1991, the DCR (MDC at the time) wildlife control program was limited to beaver and small mammal removal. Since then, the DCR has initiated the Bird Harassment Program, control of nesting Canada geese, a controlled deer hunt, and increased surveillance near intake structures for aquatic mammals. The bird harassment program has been extremely effective and has directly reduced coliform bacteria levels detected at the CVA intake. OWM also targets and monitors landfills, key sources of food for gull populations, and controls nesting of the resident Canada goose population. The control of aquatic mammals has become a critical component of OWM's waterborne disease prevention approach. A more detailed description of these management techniques can be found in the *Quabbin and Wachusett Reservoir Watersheds Aquatic Wildlife Pathogen Control Zones* (1999).

The OWM has two goals concerning wildlife populations. The first goal is to minimize or eliminate the presence of gulls, geese, and other waterfowl from the Bird Control Zone to control pathogen levels at the CVA Intake. The second goal is to prevent muskrats and beaver from occupying the Aquatic Control Zone to provide conservative protection from pathogens that can be carried and transmitted by these animals. OWM's role is to identify, monitor, and control muskrats and beaver within the defined zone.

D. OWM's Infrastructure

1. Administrative Buildings

The Quabbin Administrative Building, located in Quabbin Park, was built between 1938 and 1939. The Visitor Center as well as the professional staff offices and meeting areas are located in the building. The Quabbin Visitor Center was opened in 1984. A field office and heavy equipment garage complex is located in North New Salem.

2. Winsor Dam, Goodnough Dike, and Quabbin Hill Lookout Tower.

The Winsor Dam, located next to the Administrative Building, was built between 1935 and 1939. It is 2,640 feet in length. The Goodnough Dike was built from 1933-1938 and is 2,140 feet in length. The Quabbin Hill Lookout Tower was built from 1940-1941. The tower is 84 feet height. A visitor can see three states from the tower: Massachusetts, New Hampshire, and Connecticut

3. Boat Launch Sites

There are three boat launch sites on the Reservoir for boat fishing in designated areas: 1) Gate 8 off Route 202 in Pelham 2) Gate 31 off Route 122 in New Salem, and 3) Gate 43 off Route 32A in Hardwick, MA.

4. Quabbin Park Cemetery

The Quabbin Park Cemetery was built between 1931 and 1932. During that time, 6,601 remains were transferred. The park is 82 acres with 22 developed acres.

E. Management Areas

Within the Quabbin Reservoir Watershed there are several different types of classification systems of the lands and waters. For the purposes of managing public access, the following defined areas are used. In other cases, such as in environmental quality assessments and future forest management hydrologically defined areas are the most commonly used classification systems.

1. Public Access Management³

Quabbin Reservoir Watershed System: the land and waters under the control of DCR/DWSP⁴, within, adjacent to, or in close proximity to Quabbin Reservoir's watershed boundary, including lands within the Reservation and Off-Reservation.

³ See Quabbin Reservoir Watershed System map (Figure 3).

⁴ Formerly the Commission (Metropolitan District Commission).

Quabbin Reservoir Watershed: the natural basin from within which water drains, or in the natural course would drain, into the Quabbin Reservoir.

Quabbin Reservoir: a manmade impoundment located in central Massachusetts under the control of DCR/DWSP. The Reservoir, formed by Winsor Dam and Goodnough Dike, is the largest reservoir in Massachusetts. It is fed primarily by three branches of the Swift River and supplemented with diversions from the Ware River on a seasonal basis.

Quabbin Reservation⁵: the land and the waters within the Quabbin Reservoir Watershed System, including Prescott Peninsula, so-called, contiguous to Quabbin reservoir, and presently lying within the bounds of Routes 9, 32, 32A, 122, and 202 and being situated wholly or partly in the towns of Pelham, Belchertown, Ware, Hardwick, Petersham, New Salem, and Shutesbury, and being shown on plan of land entitled “General Plan of Quabbin Reservoir Watershed, dated February 18, 1959, Metropolitan District Commission, Water Division, Quabbin Section, Commonwealth of Massachusetts”, filed in the office of the commission. This land area is subject to stricter regulation than off-reservation lands, including the prohibition of general public hunting.

Note: **Quabbin Park** and the associated **Quabbin Park Cemetery** fall within Quabbin Reservation but are broken out separately in the Quabbin Public Access Plan since they have several access-related attributes not shared by other lands within the Reservation.

Off-Reservation: those parcels of land and the waters within the Quabbin Reservoir Watershed System which are generally outside of the bounds of the Routes 9, 32, 32A, 122, and 202, with some exceptions as shown in **Figure 3**.

2. Hydrologically Defined Areas: “Subwatersheds”

While the focus of the DWSP’s mission is the overall quality of the “watershed” and the water in the reservoir, it’s important to remember that those conditions are reflective of the collective quality of a group of smaller drainages, or “subwatersheds”, that comprise the whole. Thus, the planning process for public recreation management, land management, and other watershed activities is most logically done on a subwatershed basis. Historically, water quality monitoring has been based on the Sanitary Sub-district system – large drainage areas composed of sub-districts and compartments.

Quabbin “Subwatersheds”

A subwatershed is defined in most cases as the land area that drains to a perennial tributary of the reservoir. Those drainage areas were delineated using the MassGIS watershed delineation tool, starting from the point where the tributary met the reservoir. In most cases, these were 2nd or 3rd order streams. Where those tributaries represent higher-order streams or rivers however, they were further subdivided. This process resulted in the identification of 56 subwatersheds with the Quabbin Reservoir Watershed System. Some watershed land does not flow into tributary

⁵ Synonymous with “Quabbin Reservoir Area” as defined in the Acts of 1972, Chapter 737

streams, but rather flows directly into the reservoir along the shorelines. These “direct drainage” areas were also delineated, and if necessary, further divided into logical planning units.

Implementing Subwatershed-based Planning

The general theory behind the use of subwatershed-based planning is that as the proportion of a drainage area that is “disturbed” by activities (e.g., logging or roadwork) increases, the chances that water quality would be impacted also increases. Another consideration in subwatershed-based planning is the proximity of a subwatershed to the water intake structures. Those subwatersheds that are far removed from the intakes could be considered “less sensitive” to management impacts than those in close proximity. An example of an individual subwatershed map is shown in image below in **Figure 4**. This subwatershed is approximately 638 acres in size, with topography ranging from 531 to 954 feet. The mouth of the drainage is within 1.3 miles of the Shaft 12 intake, and approximately 6.6 miles from the CVA intake. Soil composite types in the subwatershed include: Well-drained thin soils – approximately 33% of subwatershed; Well-drained thick soils – 12%; Moderately-well drained soils – 34%; Poor to very poorly drained soils – 21%. During the past 10 years, 3 logging operations occurred in the subwatershed, covering approximately 210 acres (33% of the subwatershed). This work affected about 70 acres (11%) of the actual area, and mostly occurred on the moderately or well-drained soils in the subwatershed.

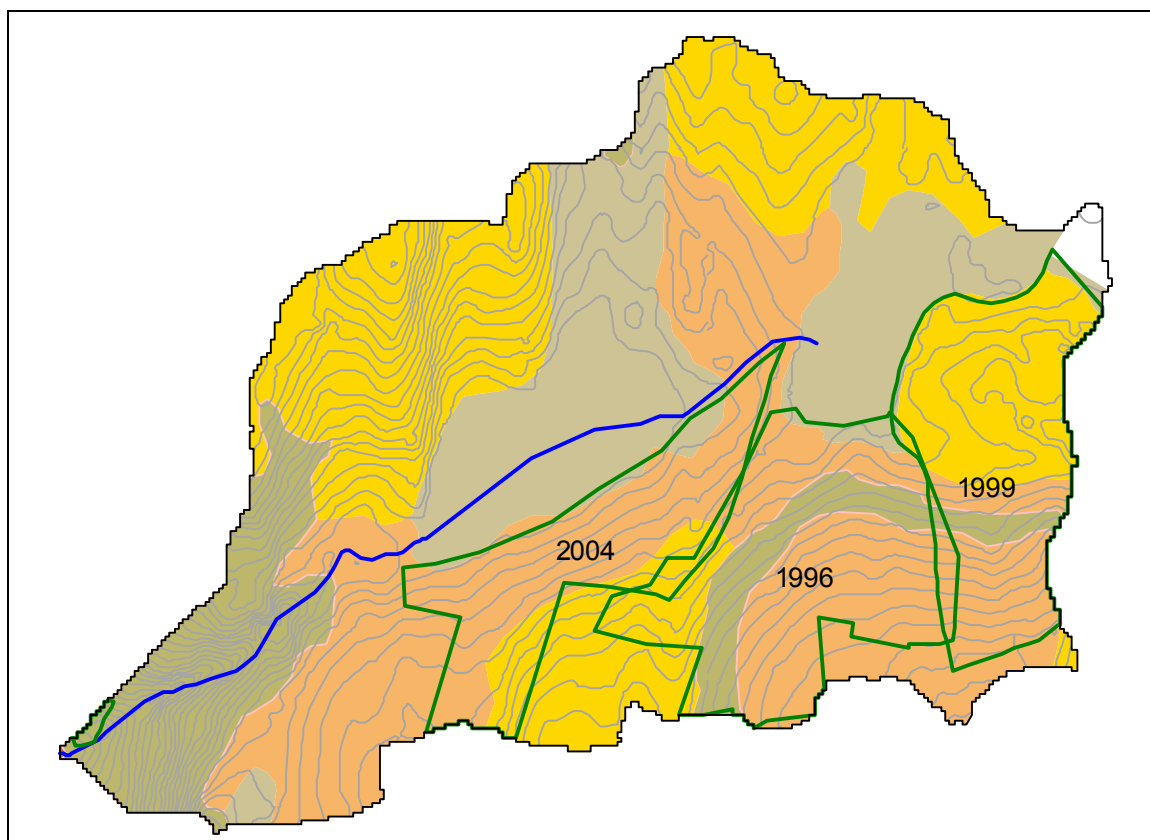


Figure 4 Example of Sub-watershed map

Source: P. Lyons, 2005